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Earth Observing System

Multi-angle
Imaging
Spectro-
Radiometer

Data Product Specification for the MISR Level 2 Land Surface Product

-Incorporating the Science Data Processing Interface Control Document

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To determine the latest released version of this document, consult the MISR web site (http://misr.jpl.nasa.gov).

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Document Change Log

Revision	Date	Affected Portions and Description
	January 25, 2018	All, original release

Which Product Versions Does this Document Cover?

Product Filename Prefix	Version Number in Filename	Brief Description
MISR_AM1_AS_LAND	F08_0023	Level 2 Land Surface

Table of Contents

1 INTRODUCTION

1.1 MISR LEVEL 2 LAND SURFACE PRODUCT

The Multi-angle Imaging SpectroRadiometer (MISR) Level 2 Land Surface products contain information on retrieved surface-leaving radiance, normalized difference vegetation index (NDVI), leaf area index (LAI), fraction of absorbed photosynthetically-active radiation (FAPAR), and ancillary information based on Level 1B2 geolocated radiances observed by MISR from the National Aeronautics and Space Adminstration (NASA) Terra Earth Observing System (EOS) satellite, which has been operational since early 2000. These data are reported for each Terra orbit on a Space Oblique Mercator (SOM) reference grid, with 1.1 km × 1.1 km spatial sampling. Files are distributed in NetCDF-4 format, which is designed to be interoperable with HDF5.

The purpose of this document is to describe the format and contents of the MISR Level 2 Land Surface product. The full details of the other MISR standard products, as well as the ancillary datasets used in their generation, can be found in their respective MISR Data Product Specifications Documents (and for earlier versions of the products in the MISR Data Products Specifications Document, Rev. S). Information concerning the MISR georegistration is contained in the MISR Science Data Product Guide. The Land Surface product is distributed with a ***Data Quality Statement*** that summarizes the strengths and known limitations of the product, and is an essential complement to the current document for scientific users of the data.

1.2 MISR DATA PRODUCTS

The MISR project is a component of the EOS Terra Mission and the EOS Data and Information System (EOSDIS), which are components of NASA's Earth Science Enterprise. An integral part of the MISR project is the Science Data Processing (SDP) of the observations coming from the MISR instrument on-board the EOS Terra satellite.

MISR SDP exists to produce science and supporting data products from MISR instrument data. All functions of the MISR SDP system are directed toward this goal. MISR SDP does not operate as an independent entity, but rather is linked to the functionality of the EOSDIS at the Langley Research Center (LaRC) Distributed Active Archive Center (DAAC). The EOSDIS Core System (ECS) ingest subsystem at the LaRC DAAC is the agent for receiving and organizing all of the input data needed by MISR SDP. These data are then made available to MISR SDP through the data server and staging facilities provided by ECS at the LaRC DAAC. After MISR standard data processing is complete, the standard output products are archived through the EOSDIS data server and made available to users through ECS client services.

The MISR Science Computing Facility (SCF) at the Jet Propulsion Laboratory (JPL) supports the development of MISR science algorithms and software, instrument calibration and performance assessment, as well as providing quality assessment and data validation services with respect to MISR SDP. The MISR SCF is used to produce software, supporting data, and

coefficients that are required to operate MISR SDP software at the LaRC DAAC. Additional algorithm development, calibration, and validation support for the Land Surface product is provided by the Climate & Radiation Laboratory at the NASA Goddard Space Flight Center (GSFC).

MISR SDP depends upon the availability of MISR instrument data, internal data sets produced at the MISR SCF, and external data sets that are products of other EOS data processing systems.

1.3 CONTROLLING DOCUMENTS

1) MISR Data System Science Requirements, JPL D-11398, September 1996 (or latest version).
2) MISR Level 1 Radiance Scaling and Conditioning Algorithm Theoretical Basis, JPL D-11507, Revision D, January 1999 (or latest version).
3) MISR Level 1 Georectification and Registration Algorithm Theoretical Basis, JPL D-11532, Revision D, November 1999 (or latest version).
4) MISR Level 1 Cloud Detection Algorithm Theoretical Basis, JPL D-13397, Revision A, November 1997 (or latest version).
5) MISR Level 1 In-flight Radiometric Calibration and Characterization Algorithm Theoretical Basis, JPL D-13398, June 1996 (or latest version).
6) MISR Level 1 Ancillary Geographic Product Algorithm Theoretical Basis, JPL D-13400, Revision B, March 1999 (or latest version).
7) MISR Level 2 Aerosol Retrieval Algorithm Theoretical Basis, JPL D-11400, Revision G, March 2008 (or latest version).
8) MISR Level 2 Surface Retrieval Algorithm Theoretical Basis, JPL D-11401, Revision E, May 2008 (or latest version).
9) MISR Level 2 Ancillary Products and Datasets Algorithm Theoretical Basis, JPL D-13402, Revision A, December 1998 (or latest version).
10) MISR Science Data Product Guide, JPL D-73355, April 2012 (or latest version).

1.4 APPLICABLE DOCUMENTS

11) SDP Toolkit Users Guide for the ECS Project, HAIS 194-809-SD4-001 (or latest version)

2 MISR LEVEL 2 LAND SURFACE DATA PRODUCT SPECIFICATION

2.1 MISR LEVEL 2 LAND SURFACE PRODUCT FILE NAMES

MISR Level 2 Land Surface Products are composed of one of the two file types listed below (Table 1).

Table 1 – MISR Level 2 Land Surface Product File Names

MISR Land Surface Product Granule Name[1]	ESDT Name
MISR_AM1_AS_LAND_ Pppp_Oooooo_Fff_vvvv.nc	MIL2ASLS
MISR_AM1_AS_LAND_FIRSTLOOK_Pppp_Oooooo_Fff_vvvv.nc	MIL2ASLF

2.2 MISR LEVEL 2 LAND SURFACE PRODUCT FILE BRIEF DESCRIPTION

The MISR Land Surface Product Generation Executable (PGE) 9b provides for the end-to-end generation of the MISR Level 2 Land Surface Product. This section gives a brief summary of the approach. For more detailed information please refer to the MISR Level 2 Land Surface Retrieval Algorithm Theoretical Basis Document (ATBD).

Initially, MISR Level 1B2 instrument data samples from all nine cameras and four spectral bands are averaged to the 1.1 km × 1.1 km (subregional) resolution required by the Land Surface algorithm. The averaged top-of-atmosphere (TOA) radiances are then normalized to an Earth-Sun distance of 1 astronomical unit (AU), converted to equivalent reflectances, corrected for out-of-band effects – including veiling light – and corrected for ozone absorption. The 1.1 km × 1.1 km subregions are then screened for contamination from sources such as clouds, sun glint over water, and topographically complex terrain.

A surface retrieval is performed on only those subregions with an estimated green band (558 nm) aerosol optical depth (AOD) less than 1.0, after applying smoothing and gap filling on AOD input from the MISR Level 2 Aerosol Product. The surface retrieval uses the corrected equivalent reflectances, smoothed aerosol parameters, and auxiliary information from the Simulated MISR Ancillary Radiative Transfer (SMART) and Canopy Architecture Radiative Transfer (CART) datasets. Spectral and photosynthetically active radiation (PAR)-integrated bihemispherical reflectance (BHR), directional-hemispherical reflectance (DHR), spectral hemispherical-directional reflectance factors (HDRFs), bidirectional reflectance factors (BRFs), and BRF model parameters, are retrieved for land and inland water type subregions. Biome type,

[1] Where ppp is the three-digit path number (001 to 233), oooooo is the six-digit orbit number, ff is the two-digit file format version (08 for this version), and vvvv is the four-digit version number (0023 for this version).

LAI, and FAPAR, are retrieved for land type subregions with NDVI greater than 0.2.

2.3 DIFFERENCES BETWEEN FIRSTLOOK AND FINAL PROCESSING

The MISR processing stream has been split into two parts – "FIRSTLOOK" and "FINAL" – to accommodate the time dependence of the Terrestrial Atmosphere and Surface Climatology (TASC) and Radiometric Camera-by-camera Cloud mask Threshold (RCCT) ancillary datasets. The TASC contains snow-ice coverage values that are updated on a monthly basis. The RCCTs are updated based on observations within a 3-month period. Rather than delaying processing of all MISR Level 2 and Level 3 data until these datasets are available, FIRSTLOOK products are generated using the TASC from the same month for the previous year and the RCCT from the same season in the previous year. When the updated TASC and RCCT datasets become available, FINAL processing is run. The FIRSTLOOK products are distinguished by the presence of FIRSTLOOK in the filenames, whereas FINAL products do not include any such designation (see Table 1).

2.4 FILE CONTENT DESCRIPTION

Content within each product file is organized as a hierarchy of groups, beginning with a top-level group, designated by the slash symbol (/). Each group can contain attributes, dimensions, fields, or other groups. Table 2 gives an overview of all groups with cross references to subsequent tables describing the content of each group. Individual dimensions and fields can also contain attributes where applicable. The set of possible attributes for individual fields and dimensions is summarized in Table 14.

Table 2 – Overview of File Content

Group Name (parent group)	**Description**	**Cross-references**
/	Top-level group, containing file attributes.	Table 3 and Table 4 (file attributes)
1.1_KM_PRODUCTS (/)	Contains fields gridded at 1.1 km resolution. This group includes the primary land surface retrieval outputs.	Table 5 (attributes) Table 6 (dimensions) Table 7 (fields)
4.4_KM_PRODUCTS (/)	Contains fields gridded at 4.4 km resolution. Fields in this group primarily represent inputs to the surface retrieval process.	Table 8 (attributes) Table 9 (dimensions) Table 10 (fields)
AUXILIARY (1.1_KM_PRODUCTS)	Contains auxiliary fields gridded at 1.1 km resolution. Includes BRF/HDRF interpolation flag, BRF model parameters (*r0, k, b*), LAI merit functions, and subregional variability of equivalent reflectance.	Table 5 (attributes) Table 6 (dimensions) Table 11 (fields)
AUXILIARY (4.4_KM_PRODUCTS)	Contains smoothed aerosol optical depths used for input to the land surface retrieval.	Table 8 (attributes) Table 9 (dimensions) Table 12 (fields)
GEOMETRY (4.4_KM_PRODUCTS)	Contains sun-satellite viewing geometry used for each retrieval. To conserve space some products are scaled to integer type, using a scale factor and offset. Note that MISR reports zenith and azimuth geometry following the direction of photon travel, which may lead to unexpected results if not properly taken into account. See Figure 36 of controlling document [3] (JPL D-11532) for MISR definitions of sun and view angles.	Table 8 (attributes) Table 9 (dimensions) Table 13 (fields)
HDFEOS INFORMATION (/)	Contains ECS Inventory Metadata, used by the DAAC, for ingesting, cataloging, and searching data products.	

Table 3 – NetCDF Climate and Forecast (CF) Standard File Attributes

Attribute Name	Value
title	MISR Level 2 Land Surface Product
institution	MISR Level 2 Land Surface Products are produced by the MISR Science Team using processing and storage facilities of the NASA Langley Research Center DAAC.
source	The land surface retrieval uses radiometric observations from the MISR instrument, aerosol optical depth from the MISR Level 2 Aerosol Product, and modeled equivalent reflectance from the Simulated MISR Ancillary Radiative Transfer (SMART) lookup table.
history	<*date*> : Initial production using software version <*version tag*>, built <*build date*>, by <*user id*>. See also Software_version_information and Input_files.
references	Data Product Specifications and Algorithm Theoretical Basis Documents are available from the Langley Atmospheric Science Data Center at https://eosweb.larc.nasa.gov/project/misr/misr_table.
Conventions	CF-1.6

Table 4 – File Attributes

Attribute Name	Definition	Data Type	Units	Valid Range
Path_number	Orbit path number for the SOM projection for this Terra orbit	32-bit integer	n/a	1 to 233
AGP_version_id	Version identifier for Ancillary Geographic Product (AGP)	32-bit integer	n/a	2
DID_version_id	Version identifier for the Digital Terrain Elevation Dataset (DTED) Intermediate Dataset (DID)	32-bit integer	n/a	4
Number_blocks	Total number of blocks	32-bit integer	n/a	1 to 180
Ocean_blocks_size Ocean_blocks.count Ocean_blocks.numbers	List of MISR blocks containing only ocean surface type in the AGP	32-bit integer	n/a	1 to 180
SOM_parameters.* (1) som_ellipsoid_a (2) som_ellipsoid_e2 (3) som_orbit.aprime (4) som_orbit.eprime (5) som_orbit.gama (6) som_orbit.nrev (7) som_orbit.ro (8) som_orbit.i (9) som_orbit.P2P1 (10) som_orbit.lambda0	SOM map projection parameters for X, Y gridded data in this file. Alternate format of the same information given in Table 5, GCTP projection parameters. (1) Semi-major axis of ellipsoid (WGS84) in meters (2) Eccentricity of ellipsoid squared (3) Not used (4) Not used (5) Not used (6) Number revolutions per ground track repeat cycle (7) Radius of circular orbit in meters (8) Orbit inclination in radians (9) Ratio of time of revolution per orbit to the length of Earth rotation (10) Longitude of ascending orbit at equator (λ_0), in radians, $\lambda_0 = \lambda_{ref} - \frac{2\pi}{233} \cdot path\_number$ $\lambda_{ref} = 129.3056 \cdot \frac{\pi}{180}$	64-bit float, 32-bit integer	meters, radians, n/a	(1) 6378137.0 meters (2) 0.006694348 (3) 1.0 (4) 1.0 (5) 1.0 (6) 233 (7) 7078040.8 meters (8) 1.715725326 radians (9) 0.068666667 (10) 0 to -2π
Cam_mode	Indicates whether the data in this file was obtained in MISR global mode or local mode	32-bit integer	n/a	0 = local 1 = global
Num_local_modes	Number of MISR local mode acquisitions contained in this file	32-bit integer	n/a	0 to 6 0 if data is global mode

Table 4 – File Attributes

Local_mode_site_name	Geographical name of the first local mode site contained in this file (if applicable)	String	n/a	
Orbit_QA	Indication of the overall quality of the orbit data, based on analysis of quality flags in the spacecraft attitude and ephemeris data. Geolocation accuracy may be impaired for orbits with poor quality orbit data.	32-bit float	n/a	-9999.0 = No retrieval -1.0 = Poor 0.0 = Nominal
SOM_map_minimum_corner.x SOM_map_maximum_corner.x SOM_map_minimum_corner.y SOM_map_maximum_corner.y	Map corner coordinates of SOM projection for X, Y gridded data in this file. X axis increases with time along the spacecraft ground track. Y axis increases with sample number, perpendicular to the ground track. See Table 5, GCTP_projection parameters.	64-bit float	meters	X: 6 million to 33 million Y: -12 million to 12 million
Start_block End_block	MISR block numbers corresponding to the first and last blocks processed for this product	32-bit integer	n/a	1 to 180 (Start_block ≤ End_block)
Local_granule_id	Name of this file	String	n/a	
Local_version_id	Software version identifier	String	n/a	
PGE_version	Version of the PGE used to generate this file	String	n/a	
Equator_crossing_longitude Equator_crossing_time Range_beginning_time Range_ending_time	Alternate source of the same named parameters in ECS inventory metadata. These are only provided for convenience of access to inventory metadata elements and should not be used as precise measurements relative to surface retrievals. See Time field (Table 7) for sources of time information.	64-bit float String	degrees	longitude: -180 to +180 time: ISO 8601 format, e.g. 2004-06-30T21:17:11.711120Z
Orbit_number	Terra orbit number	32-bit integer	n/a	
Software_version_information	Software version information	String	n/a	
Software_version_tag	Tag identifying software version	String	n/a	
Software_build_date	Date and time of software build	String	n/a	ISO 8601 format, e.g. 2017-03-07T00:07:01Z
Input_files	List of input files used in data processing	String	n/a	
config.*	Configurable parameters used for this product version	String		

Table 5 – 1.1_KM_PRODUCTS Attributes

Attribute Name	Definition	Data Type	Units	Valid Range
GCTP projection parameters	SOM projection parameters represented as a 13-parameter array, compatible with the General Cartographic Transformation Package (GCTP), SOM A (code 22) format, detailed in the HDF-EOS User's Guide. Relevant parameters are: (1) Semi-major axis of ellipsoid (WGS84) (2) Eccentricity of ellipsoid squared (expressed as a negative value) (4) Inclination of orbit at ascending node (packed degrees minutes seconds (DMS) format) (5) Longitude of ascending orbit at equator (packed DMS format). See Table 4, SOM_parameters, λ_0 (9) Orbit period in minutes Parameters 3, 6 through 8, and 10 through 13 are always zero.	64-bit float	meters, degrees, minutes	(1) 6378137.0 meters (2) -0.006694348 (3) 0 (4) 98018013.75 (5) 0 to 360 degrees (6) 0 (7) 0 (8) 0 (9) 98.88 minutes (10) 0 (11) 0 (12) 0 (13) 0
block_size_in_lines	Size of a MISR block on the SOM X axis (along track)	32-bit integer	lines	128
block_size_in_samples	Size of a MISR block on the SOM Y axis (across-track)	32-bit integer	samples	512
resolution_in_meters	Resolution of this grid	32-bit integer	meters	1100

Table 6 – 1.1_KM_PRODUCTS Dimensions

Dimension Name *[CF standard_name]*	**Description**	**Data Type**	**Units**	**Valid Range**
X_Dim *[projection_x_coordinate]*	SOM projection X axis (along-track)	64-bit float	meters	6 million to 33 million
Y_Dim *[projection_y_coordinate]*	SOM projection Y axis (across-track)	64-bit float	meters	-12 million to 12 million
Block_Number	MISR block number	32-bit integer	n/a	1 to 180
Camera_Dim	Camera dimension in the order of acquisition by the instrument	32-bit integer	n/a	1 = D forward 2 = C forward 3 = B forward 4 = A forward 5 = A nadir 6 = A aftward 7 = B aftward 8 = C aftward 9 = D aftward
Band_Dim	MISR band number	32-bit integer	n/a	1 = blue (446 nm) 2 = green (558 nm) 3 = red (672 nm) 4 = nir (867 nm)
Biome_Type_Dim	Vegetated biome types	32-bit integer	n/a	1 = grasses and cereal crops 2 = shrubland 3 = broadleaf_crops 4 = savanna 5 = broadleaf_forest 6 = needleleaf_forest

Table 7 – 1.1_KM_PRODUCTS Fields

Field Name *[CF standard_name]* Parameter Description	**Dimensions**	**Data Type**	**Units**	**Flag Values**
Block_Start_X_Index Offset of first line on SOM x-axis (along-track)	Block	32-bit integer	n/a	
Block_Start_Y_Index Offset of first sample on SOM y-axis (across-track)	Block	32-bit integer	n/a	
Time *[time]* Approximate nadir view acquisition time in seconds since epoch, given by units (See Table 14, calendar). Accuracy of ±30 seconds can be assumed. More precise time information can be obtained from other sources.*	X	64-bit float	seconds since epoch	
Latitude *[latitude]* Geodetic latitude of retrieval	X, Y	32-bit float	degrees north	-9999.0 = Fill
Longitude *[longitude]* Geodetic longitude of retrieval	X, Y	32-bit float	degrees east	-9999.0 = Fill
Hemispherical_Directional_ Reflectance_Factor HDRF for non-isotropic incident radiation, which is the ratio of the radiance reflected from the surface to that from an ideal Lambertian target illuminated under identical atmospheric conditions (ATBD eqs. 29 and 40)	X, Y, Band, Camera	16-bit unsigned integer (See Table 14, scale_factor)	n/a	65533 = Fill 65534 = Underflow 65535 = Overflow
Hemispherical_Directional_ Reflectance_Factor_Uncertainty Square root of the variance in the derived HDRF based on propagation of errors (ATBD eq. 50)	X, Y, Band, Camera	16-bit unsigned integer (See Table 14, scale_factor)	n/a	65533 = Fill 65534 = Underflow 65535 = Overflow
Bi-Hemispherical_Reflectance BHR, or albedo, for non-isotropic incident radiation, which is the ratio of the radiant exitance to the total surface irradiance (ATBD eqs. 13 and 38)	X, Y, Band	8-bit unsigned integer (See Table 14, scale_factor)	n/a	253 = Fill 254 = Underflow 255 = Overflow

Bi-Hemispherical_Reflectance_ Relative_Uncertainty Square root of the variance in the BHR based on propagation of errors relative to the aerosol model used for the atmosphere (ATBD eq. 58)	X, Y, Band	8-bit unsigned integer (See Table 14, scale_factor)	n/a	253 = Fill 254 = Underflow 255 = Overflow
Bidirectional_Reflectance_Factor BRF, which is the ratio of the reflected radiant flux from the target to the reflected radiant flux from an ideal Lambertian surface with the same viewing geometry illuminated from a single direction (ATBD eq. 89)	X, Y, Band, Camera	16-bit unsigned integer (See Table 14, scale_factor)	n/a	65533 = Fill 65534 = Underflow 65535 = Overflow
Directional_Hemispherical_ Reflectance DHR, which is the hemispherically integrated BRF, and corresponds to the albedo of the surface under pure, direct illumination (black-sky albedo) (ATBD eq. 87)	X, Y, Band	8-bit unsigned integer (See Table 14, scale_factor)	n/a	253 = Fill 254 = Underflow 255 = Overflow
Normalized_Difference_Vegetation_ Index *[normalized difference vegetation index]* NDVI is the ratio of the difference between the DHR in the NIR and red bands to the sum of the DHR in the NIR and red bands. NDVI is reported where the AGP surface type is land (1), and DHR is available in both bands (ATBD eq. 101)	X, Y	8-bit unsigned integer (See Table 14, scale_factor)	n/a	253 = Fill 254 = Underflow 255 = Overflow
Biome_Best_Estimate Best estimate of biome type based on calculated NDVI, DHR, BHR, and LAI values (ATBD sec. 3.3.6.1)	X, Y	8-bit unsigned integer	n/a	253 = Fill 1 = grasses and cereal crops 2 = shrubland 3 =broadleaf crops 4 = savanna 5 = broadleaf forest 6 = needleleaf forest 7 = unknown 8 = ambiguous 9 = not land 10 = barren

Leaf_Area_Index_Best_Estimate *[leaf_area_index]* LAI, which is the amount of one-sided green leaf area per unit ground area integrated from the top of the canopy to the ground, reported for the best estimate biome type. Requires NDVI > 0.2 (ATBD sec. 3.3.7.4)	X, Y	32-bit float	n/a	-9999.0 = Fill
Leaf_Area_Index_Best_Estimate_QA Quality assurance (QA) indicator for best estimate of LAI, for the best estimate biome type (ATBD sec. 3.3.6.1)	X, Y	8-bit unsigned integer	n/a	253 = Fill 0 = tests 1 and 2 passed 1 = test 1 passed, test 2 failed 2 = test 1 failed, test 2 passed 3 = test 1 failed, test 2 not attempted 4 = no attempt due to poor solar viewing geometry
Leaf_Area_Index_QA QA indicator of LAI, for all vegetated biome types. (ATBD sec. 3.3.6.1)	X, Y, Biome	8-bit unsigned integer	n/a	253 = Fill 0 = tests 1 and 2 passed 1 = test 1 passed, test 2 failed 2 = test 1 failed, test 2 passed 3 = test 1 failed, test 2 not attempted 4 = no attempt due to poor solar viewing geometry
Fractional_Absorbed_Photosynthetically_Active_Radiation_Best_Estimate *[fraction of surface downwelling photosynthetic radiative flux absorbed by vegetation]* Best estimate of FAPAR, which is the fraction of incident photosynthetically active radiation that is absorbed by photosynthesizing tissue in a plant canopy. Requires NDVI > 0.2. (ATBD eq. 144)	X, Y	32-bit float	n/a	-9999.0 = Fill
Photosynthetically_Active_Radiation_Integrated_Bi-Hemispherical_Reflectance BHR in the photosynthetically active radiation (PAR) regime, 400 - 700 nm. Requires NDVI > 0.2. (ATBD eq. 98)	X, Y	32-bit float	n/a	-9999.0 = Fill
Photosynthetically_Active_Radiation_Integrated_Directional_Hemispherical_Reflectance DHR in the photosynthetically active radiation (PAR) regime, 400 - 700 nm. Requires NDVI > 0.2. (ATBD eq. 100)	X, Y	32-bit float	n/a	-9999.0 = Fill

Table 8 – 4.4_KM_PRODUCTS Attributes

Attribute Name	Definition	Data Type	Units	Valid Range
GCTP_projection_parameters	Same as in Table 5			
block_size_in_lines	Size of a MISR block on the SOM X axis (along track)	32-bit integer	Lines	32
block_size_in_samples	Size of a MISR block on the SOM Y axis (across-track)	32-bit integer	Samples	128
resolution_in_meters	Resolution of this grid.	32-bit integer	meters	4400

Table 9 – 4.4_KM_PRODUCTS Dimensions

Dimension Name *[CF standard_name]*	Description	Data Type	Units	Valid Range
X_Dim *[projection_x_coordinate]*	SOM projection X axis (along-track)	64-bit float	meters	6 million to 33 million
Y_Dim *[projection_y_coordinate]*	SOM projection Y axis (across-track)	64-bit float	meters	-12 million to 12 million
Block_Number	MISR block number	32-bit integer	n/a	1 to 180
Camera_Dim	Camera dimension in the order of acquisition by the instrument	32-bit integer	n/a	1 = D forward 2 = C forward 3 = B forward 4 = A forward 5 = A nadir 6 = A aftward 7 = B aftward 8 = C aftward 9 = D aftward
Band_Dim	MISR band number	32-bit integer	n/a	1 = blue (446 nm) 2 = green (558 nm) 3 = red (672 nm) 4 = nir (867 nm)
Mixture_Dim	Aerosol mixture number	32-bit integer	n/a	1 to 74

Table 10 – 4.4_KM_PRODUCTS Fields

Field Name *[CF standard_name]* Parameter Description	**Dimensions**	**Data Type**	**Units**	**Flag Values**
Block_Start_X_Index Offset of first line on SOM x-axis (along-track)	Block	32-bit integer	n/a	
Block_Start_Y_Index Offset of first sample on SOM y-axis (across-track)	Block	32-bit integer	n/a	
Time *[time]* Approximate nadir view acquisition time in seconds since epoch, given by units (See Table 14, calendar). Accuracy of +/- 30 seconds can be assumed. More precise time information can be obtained from other sources.*	X	64-bit float	seconds since epoch	
Latitude *[latitude]* Geodetic latitude of retrieval	X, Y	32-bit float	degrees north	-9999.0 = Fill
Longitude *[longitude]* Geodetic longitude of retrieval	X, Y	32-bit float	degrees east	-9999.0 = Fill
Elevation *[surface_height_above_reference_ellipsoid]* Surface elevation relative to the WGS84 ellipsoid	X, Y	16-bit integer	meters	-9999 = Fill
Normalized_Black_Surface_Irradiance Modeled black surface irradiance input. Calculated as a mean of successful aerosol mixtures (ATBD eqs. 61 and 63)	X, Y, Band	32-bit float	n/a	-9999.0 = Fill
Normalized_Black_Surface_Irradiance_Uncertainty Square root of the variance in the normalized black surface irradiance for successful aerosol mixtures (ATBD eq. 62 top)	X, Y, Band	32-bit float	n/a	-9999.0 = Fill
Bottom_Of_Atmosphere_Bihemispherical_Albedo Modeled bottom of atmosphere (BOA) bihemispherical albedo input. Calculated as a mean of successful aerosol mixtures (s_λ in ATBD eq. 47)	X, Y, Band	32-bit float	n/a	-9999.0 = Fill
Bottom_Of_Atmosphere_Bihemispherical_Albedo_Uncertainty Square root of the variance in the modeled BOA bihemispherical albedo, for successful aerosol mixtures (ATBD eq. 62 bottom)	X, Y, Band	32-bit float	n/a	-9999.0 = Fill

Table 11 – AUXILIARY Fields (1.1_KM_PRODUCTS)

Field Name *[CF standard_name]* Parameter Description	**Dimensions**	**Data Type**	**Units**	**Flag Values**
BRF_HDRF_Interpolation_Flag Indicates where BRF and HDRF are obtained using equivalent reflectance input that has been interpolated (or extrapolated) from adjacent camera views	X, Y, Band, Camera	8-bit integer	n/a	-1 = Fill 0 = not interpolated 1 = interpolated
mRPV_Model_r0 First parameter in the parametric modified Rahman-Pinty-Verstraete (mRPV) surface BRF model (ATBD eq. 78 free parameter r_0)	X, Y, Band	16-bit unsigned integer (See Table 14, scale_factor)	n/a	65533 = Fill 65534 = Underflow 65535 = Overflow
mRPV_Model_k Second parameter in the parametric mRPV surface BRF model (ATBD eq. 78 free parameter k)	X, Y, Band	8-bit unsigned integer (See Table 14, scale_factor)	n/a	253 = Fill 254 = Underflow 255 = Overflow
mRPV_Model_b Third parameter in the parametric mRPV surface BRF model (ATBD eq. 78 free parameter b)	X, Y, Band	8-bit unsigned integer (See Table 14, scale_factor)	n/a	253 = Fill 254 = Underflow 255 = Overflow
mRPV_Model_Fit_Residual An estimate of the quality of the fit between the retrieved BRF and the modeled BRF (ATBD eq. 89a)	X, Y, Band	16-bit unsigned integer (See Table 14, scale_factor)	n/a	65533 = Fill 65534 = Underflow 65535 = Overflow
Mean_Leaf_Area_Index_Test_1 *[leaf_area_index]* Mean LAI, first test (6 biomes) (ATBD eq. 119)	X, Y, Biome	8-bit unsigned integer (See Table 14, scale_factor)	n/a	253 = Fill 254 = Underflow 255 = Overflow
Leaf_Area_Index_Merit_Function_Test_1 Delta LAI, first test (6 biomes) (ATBD eq. 120) (ATBD sec. 3.3.6.2)	X, Y, Biome	32-bit float (sign flag)	n/a	-9999.0 = Fill Take absolute value to remove sign flag Negative sign indicates saturation Positive sign indicates no saturation
Number_Passing_LAI_Values_Test_1 Number of good fits after first test (6 biomes) (ATBD eq. 118)	X, Y, Biome	32-bit integer	count	-9999 = Fill

Mean_Leaf_Area_Index_Test_2 *[leaf_area_index]* Mean LAI, second test (6 biomes) (ATBD eq. 119)	X, Y, Biome	8-bit unsigned integer (See Table 14, scale_factor)	n/a	253 = Fill 254 = Underflow 255 = Overflow
Leaf_Area_Index_Merit_Function_Test_2 Delta LAI, second test (6 biomes) (ATBD eq. 120) (ATBD sec. 3.3.6.2)	X, Y, Biome	32-bit float (sign flag)	n/a	-9999.0 = Fill Take absolute value to remove sign flag Negative sign indicates saturation Positive sign indicates no saturation
Number_Passing_LAI_Values_Test_2 Number of good fits after second test (6 biomes) (ATB eq. 118)	X, Y, Biome	32-bit integer	count	-9999 = Fill
Equivalent_Reflectance_Subregion_Variability The standard deviation of the nadir equivalent reflectances divided by the mean value for each band (ATBD eq. 1)	X, Y, Band	8-bit unsigned integer (See Table 14, scale_factor)	n/a	253 = Fill 254 = Underflow 255 = Overflow
AGP_Surface_Type Surface type from AGP	X, Y	8-bit unsigned integer	n/a	253 = Fill 0 = shallow ocean 1 = land 2 = coastline 3 = shallow inland water 4 = ephemeral water 5 = deep inland water 6 = deep ocean
Suitable_For_Surface_Retrieval Indicates locations suitable for surface retrieval after applying all suitability tests	X, Y, Band, Camera	8-bit integer	n/a	-1 = Fill 0 = not suitable 1 = suitable

Table 12 – AUXILIARY Fields (4.4_KM_PRODUCTS)

Field Name Parameter Description	Dimensions	Data Type	Units	Flag Values
Smoothed_Aerosol_Optical_Depth_Per_Mixture *[atmosphere optical thickness due to ambient aerosol particles]* AOD at 550 nm after applying smoothing and gap filling algorithms. These are the AODs and mixtures used in the surface retrieval. Set to fill value for mixtures that are not used	X, Y, Mixture	32-bit float	n/a	-9999.0 = Fill
Smoothed_Aerosol_Optical_Depth *[atmosphere optical thickness due to ambient aerosol particles]* Mean of smoothed AOD at 550 nm	X, Y	32-bit float	n/a	-9999.0 = Fill

Table 13 – GEOMETRY Fields (4.4_KM_PRODUCTS)

Field Name *[CF standard_name]* Parameter Description	**Dimensions**	**Data Type**	**Units**	**Flag Values**
Solar_Zenith_Angle *[solar_zenith_angle]* The angle of the sun relative to overhead (0°)	X, Y	32-bit float	angular degree	-9999.0 = Fill
Solar_Azimuth_Angle *[solar_azimuth_angle]* Angle measured clockwise relative to local north of the projection of the solar illumination vector onto a horizontal plane. The illumination vector points in the direction of photon travel, away from the Sun. The opposing vector, pointing *toward* the Sun, is given by [(Solar_Azimuth_Angle + 180°) modulo 360°]	X, Y	32-bit float	angular degree	-9999.0 = Fill
View_Zenith_Angle *[sensor_zenith_angle]* Zenith angle of the observation relative to nadir (0°)	X, Y, Camera	16-bit unsigned integer (See Table 14, scale_factor)	angular degree	65533 = Fill 65534 = Underflow 65535 = Overflow
View_Azimuth_Angle *[sensor_azimuth_angle]* Angle measured clockwise relative to local north of the projection of the view vector onto a horizontal plane. The view vector points in the direction of photon travel.	X, Y, Camera	16-bit unsigned integer (See Table 14, scale_factor)	angular degree	65533 = Fill 65534 = Underflow 65535 = Overflow
Scattering_Angle *[scattering_angle]* The angle between the vector pointing in the direction of travel of the direct sunlight and the vector pointing toward the instrument	X, Y, Camera	16-bit unsigned integer (See Table 14, scale_factor)	angular degree	65533 = Fill 65534 = Underflow 65535 = Overflow
Glint_Angle *[sunglint_angle]* The angle between the vector pointing in the direction of specularly reflected direct sunlight from a horizontal surface and the vector pointing toward the instrument	X, Y, Camera	16-bit unsigned integer (See Table 14, scale_factor)	angular degree	65533 = Fill 65534 = Underflow 65535 = Overflow

Table 14 – Common Attributes of Dimensions and Fields (Where Applicable)

Attribute Name	Description

coordinates	NetCDF CF standard attribute for specifying alternative sets of coordinate values. In this product, spatially gridded data is implicitly geolocated by the SOM X and Y coordinates of each grid cell. Latitude and Longitude fields serve as an alternative source of geolocation. The Time field serves as an alternative to the SOM X (along-track) coordinate. Example:
	
	`uint16 Biome_Best_Estimate(X, Y);`
	`:coordinates = "Latitude Longitude Time";`

calendar	CF standard attribute specifying reference calendar for time units. Value of "standard" specifies standard Gregorian/Julian calendar. Example:
	
	`double Time(X);`
	`:calendar="standard"`
	`:units="seconds since 2007-01-24T05:05:38.043934Z"`

units	CF standard attribute specifying units of measurement (e.g. meters, seconds). See calendar example, above.

long_name
comment
	CF standard attributes for specifying more descriptive information about a field.
	Example:
	
	`short Elevation(X, Y);`
	`:standard_name="surface_height_above_reference_ellipsoid"`
	`:long_name="Surface elevation"`
	`:comment="Reference ellipsoid is WGS84"`

flag_values,
flag_meanings
	CF standard attributes for assigning meanings to numeric values. Example:
	
	`int Camera_Dim(Camera_Dim);`
	`:flag_values = 1, 2, 3, 4, 5, 6, 7, 8, 9`
	`:flag_meanings = "D_forward C_forward B_forward A_forward A_nadir A_aftward B_aftward C_aftward D_aftward"`

standard_name	CF standard attribute for specifying the common name of a field. Example:
	
	`double X_Dim(X_Dim);`
	`:axis="X"`
	`:long_name=" Space-oblique Mercator Along-Track"`
	`:standard_name="projection_x_coordinate"`
	`:units="meters"`

axis	CF standard attribute for specifying coordinate axis associated with a dimension. See standard_name example, above.

scale_factor,
add_offset,
valid_range
 	
(underflow)
(overflow)
	CF standard attributes for packed data. To translate packed (integer) values to real (float) values:
	
	*float_value = integer_value * scale_factor + add_offset*
	
	The valid range of integer values for which the above formula holds is given by valid_range. Integer values outside the valid range should be interpreted as either fill values or flag values (if provided). Example:
	
	`uint16 Hemispherical_Directional_Reflectance_Factor(X, Y, Camera, Band);`
	`:scale_factor = 7.62986E-5`
	`:add_offset = 0.0`
	`:valid_range = 0, 65532`
	`:flag_values = 65534, 65535`
	`:flag_meanings = "underflow, overflow"`
	`:_FillValue = 65533`
	
	Underflow and overflow flags indicate values outside the allowed range. For example, an HDRF of -0.1 cannot be numerically represented in the above example. Underflow represents values less than the minimum allowed. Overflow represents values greater than the maximum allowed.

_FillValue	CF standard attribute for specifying fill value.

* The Time variable is derived by interpolation of Block Center Time samples reported in the An camera GRP_ELLIPSOID product. This approximates the average time of acquisition of the 9 MISR camera views at a given location. The offset in time between the first (Df) camera view and the last (Da) camera view, at any given location, is approximately 7 minutes. More precise acquisition time per camera, per sample location, can be obtained from coefficients recorded in the PerBlockMetadataRad table of the GRP_ELLIPSOID products.

3 Appendix

3.1 ACRONYM LIST

AGP .....Ancillary Geographic Product
AOD.....Aerosol Optical Depth
ATBD.....Algorithm Theoretical Basis Document
AU.....Astronomical Unit
BHR .....Bihemispherical Reflectance
BOA .....Bottom Of Atmosphere
BRF .....Bidirectional Reflectance Factor
CART.....Canopy Architecture Radiative Transfer
CF.....Climate and Forecast
DAAC .....Distributed Active Archive Center
DHR .....Directional-Hemispherical Reflectance
DID .....DTED Intermediate Dataset
DMS.....Degrees Minutes Seconds
DTED.....Digital Terrain Elevation Dataset
ECS .....EOSDIS Core System
EOS .....Earth Observing System
EOSDIS .....Earth Observing System Data and Information System
ESDT.....Earth Science Data Type
FAPAR.....Fraction of Absorbed Photosynthetically-Active Radiation
GCTP .....General Cartographic Transformation Package
GSFC .....Goddard Space Flight Center
HDF .....Hierarchical Data Format
HDF-EOS.....Hierarchical Data Format for EOS
HDRF .....Hemispherical-Directional Reflectance Factor
ISO .....International Organization for Standardization
JPL .....Jet Propulsion Laboratory
LAI.....Leaf Area Index
LaRC.....Langley Research Center
MISR.....Multi-angle Imaging SpectroRadiometer
mRPV.....Modified Rahman-Pinty-Verstraete

NASA.....National Aeronautics and Space Administration
NDVI.....Normalized Difference Vegetation Index
NetCDF .....Network Common Data Format
PAR.....Photosynthetically Active Radiation
PGE.....Product Generation Executable
QA.....Quality Assurance
RCCT .....Radiometric Camera-by-camera Cloud mask Threshold
SCF .....Science Computing Facility
SDP .....Science Data Processing
SMART.....Simulated MISR Ancillary Radiative Transfer
SOM.....Space-Oblique Mercator
TASC .....Terrestrial Atmosphere and Surface Climatology
TOA .....Top-Of-Atmosphere
WGS84.....World Geodetic System 1984